Increasing the Bandwidth of a Meander Line Antenna Consisting of Two Strips

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1. Introduction

In recent years, small antennas for handsets in personal communication systems have been required. There is a meander line antenna (MLA) which can be used as such a small antenna. The size of the MLA is small, on the order of 0.1 wavelength. The features of MLA consisting of one wire have been shown in [1]-[3]. A meander line antenna consisting of two strips has been suggested[4]. The MLA has a feature that its input impedance can be easily matched by use of impedance step-up and balance mode impedance loading. But increasing of the bandwidth of an MLA through use of two strip geometry has not been accomplished so far.

In this paper, a method for increasing the bandwidth of the 2-strip MLA is described. An equivalent circuit of the MLA is represented by use of the balance mode impedance as an open- or short-circuited shunt stub. On the basis of the equivalent circuit, numerical analysis of the impedance characteristics of the 2-strip MLA is carried out. In the analysis, the contribution of the parameters of the 2-strip MLA towards increasing the bandwidth are discussed.

2. Numerical Analysis

An analytical model of the 2-strip MLA is shown in Fig.1. This antenna consists of two meander lines. One of these is fed at the bottom while the other one is grounded. The current flow in element 1 is different from that in element 2. The currents in each element flows in the balance and unbalance modes as shown in Fig.2. The balance mode corresponds to a transmission line mode and contributes to the impedance matching, while the unbalance mode corresponds to an antenna mode and gives rise to the radiation. The impedance characteristics of an MLA consisting of one strip is shown in Fig.3. The characteristic was calculated by use of the method of moments[5]. A matching circuit is required because the radiation resistance of the one strip MLA is too small. The 2-strip MLA has an impedance step-up effect, and therefore, the impedance of the MLA is matched to itself. The equivalent circuit is shown in Fig.4. In the equivalent circuit, Z_b and Z_u are equivalent to the impedance in balance and unbalance modes, respectively. n^2 is the step-up ratio of the transformer. Z_b represents the impedance of the open- or short-circuited shunt stub. Z_c and L are the characteristic impedance of the stub and the length of the stub, respectively. Z_b and Z_u are formulated as follows:

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$$Z_b = \begin{cases} -j\dfrac{Z_C}{\tan(2\pi L/\lambda)} & \text{(for open-circuited stub)} \\ jZ_C\tan(2\pi L/\lambda) & \text{(for short-circuited stub)} \end{cases} \quad (1)$$

$$Z_u = \frac{1}{n^2}\left[R + jRQ\left(\frac{f}{f_0} - \frac{f_0}{f}\right)\right] \quad (2)$$

where

n^2 = impedance step up ratio
R = radiation resistance
f_0 = resonant frequency
Q = quality factor
L = length of the stub.

Analysis of the equivalent circuit shows how it is possible to increase the bandwidth.

3. Numerical Results

Examples of the impedance characteristics calculated by use of the equivalent circuit in the case of a short-circuited stub are shown in Fig.5. In Fig.5 (a), the α-shaped feature is a broadband feature that depends on the ratio of L to λ, (L/λ). The α-shaped feature becomes inductive impedance when the value of L/λ is less than 0.75, while it becomes capacitive impedance when the value of L/λ is greater than 0.75. When the value of L/λ is 0.75, that is, when Z_b in equation (1) is infinite at the resonant frequency, the most broadband feature occurs.

The impedance characteristics for different values of Z_c are shown in Fig.5 (b). The value of Z_c effects the value of resistance of the α-shaped feature. In this example, the broadband characteristic is seen when the value of Z_c is around 20 ohms.

The impedance characteristics and VSWR when sufficient broadband are achieved are shown in Fig.6. In this figure, the characteristics in the case of the equivalent circuit without the stub are also shown. From the results of the analysis, the ratio of bandwidth compared with center frequency is 12.1% when the broadband is achieved.

4. Conclusion

Increasing the bandwidth of the 2-strip MLA was considered by use of its equivalent circuit. The impedance characteristic in balance mode was represented by an open- or short-circuited stub. It was made clear that the broadband was achieved when the length of the stub and characteristic impedance were of the appropriate values.

Reference

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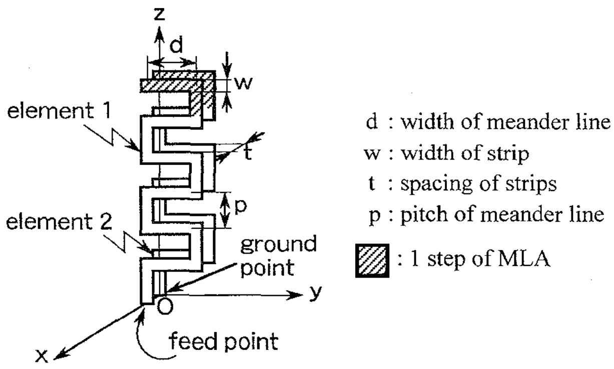


Fig.1 : Geometry of a 2-strip MLA

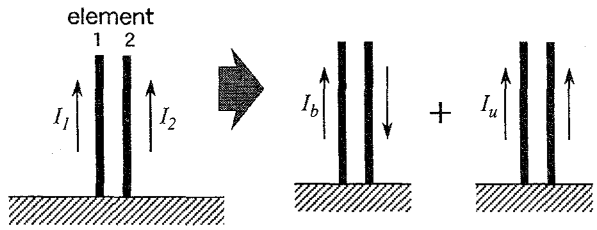


Fig.2 : Currents in balance and unbalance modes.

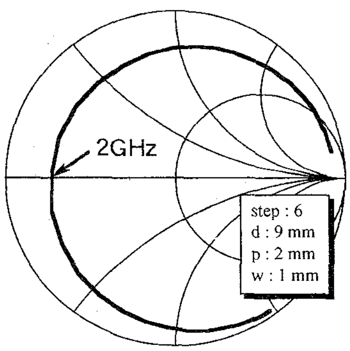


Fig.3 : Impedance characteristics of a 1-strip MLA calculated by use of the method of moments (frequency : 1.5-3GHz).

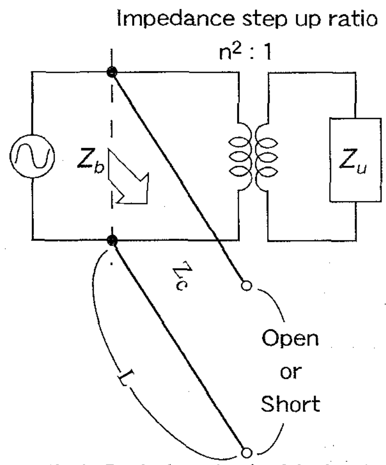
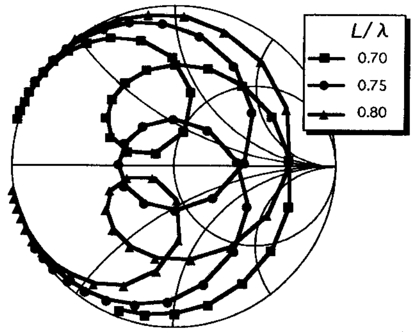
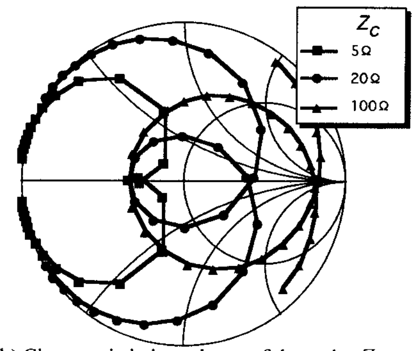


Fig.4 : Equivalent circuit of the 2-strip MLA.



(a) The ratio of length of the stub to wavelength : L/λ

(R=25Ω, Q=15, Z_C=20Ω)

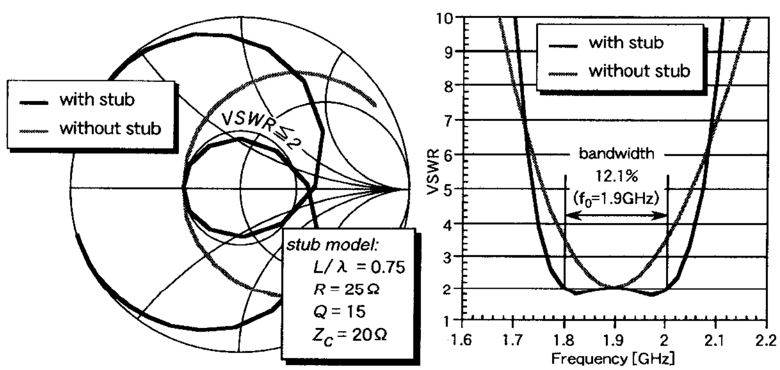


(b) Characteristic impedance of the stub : Z_C

(L/λ=0.75, R=25Ω, Q=15)

Fig.5 : Impedance characteristics that depend on the parameters.

(frequency : 1.5-2.4GHz, f_0 : 1.9GHz, 25MHz step)



(a) Smith chart (b) VSWR

Fig.6 : Impedance characteristics and VSWR.